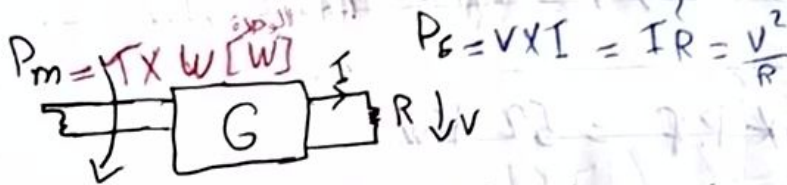


#Kojok

Dc - Machine

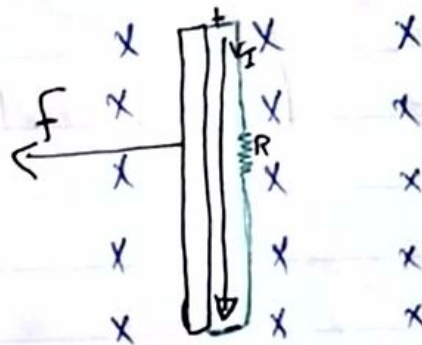
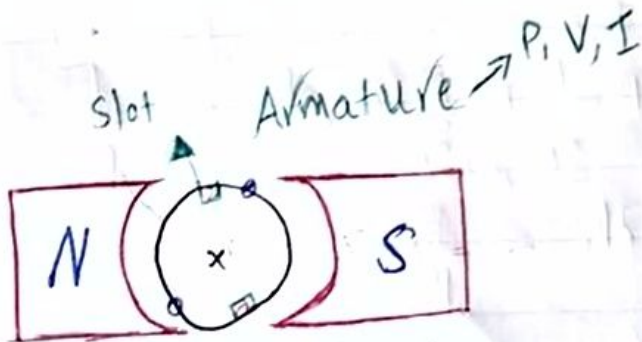
- Dc generators
- Dc Motors



* كيف يتم الحصول على الحركة

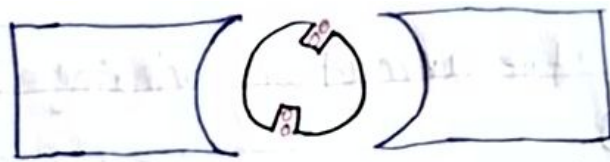
- 1) fuel
- 2) water (hydro)
- 3) Steam
- 4) wind (prime mover)

Generator action



single layer

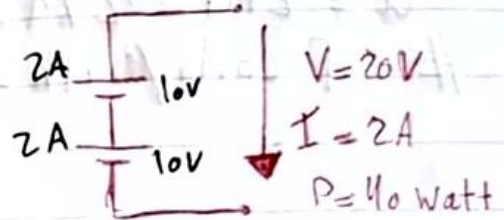
of Conductor $Z = 2CN \Rightarrow$ # of turns
 # of coil



24 slots
Single layer
of Coils = 12

double layer

double layer
of Coils = 24



* Armature winding Connection

1) lap winding $a = m p$ $m = \# \text{ of poles}$

2) wave winding $a = 2m$ $\text{double} = 2$

Ex: DC generator with 48 slots, single-layer, $P=4$

1) Draw the armature winding in case simplex lap winding

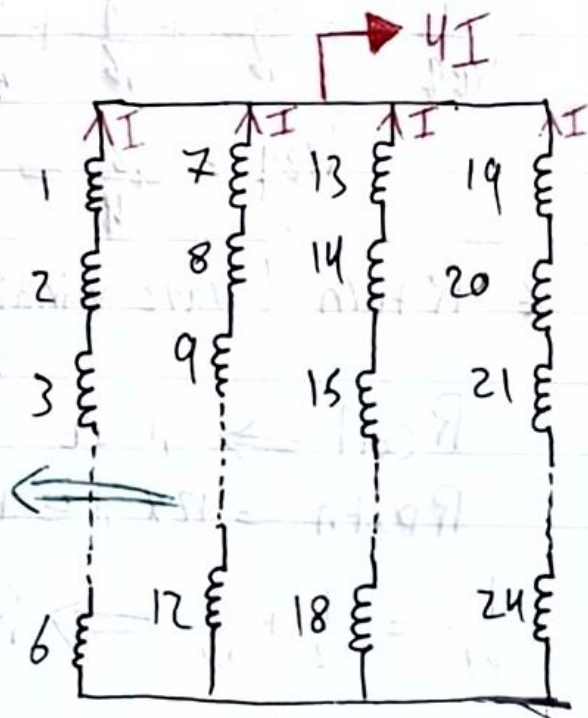
$$\# \text{ of Coils} = \frac{1}{2} \times 48 = 24 \text{ Coils}$$

$$a = m p = 1 \times 4 = 4$$

$$\# \text{ of Coils / path} = \frac{24}{4} = 6 \text{ Coils}$$

$$P = 6E \times 4I$$

$$= 24EI$$



2) Draw the armature winding in case simplex wave winding

$$\# \text{ of coils} = 24$$

$$a = 2m = 2 \times 1 = 2$$

$$\# \text{ of coils/path} = 24/2 = 12$$

$$P = 12 E \times 2I$$

$$= 24 EI$$

* R turn (lap winding) $\rightarrow 10 \Omega$

of for each coil = 10

$$R_{\text{coil}} = 10 \times 1 = 10 \Omega$$

$$R_{\text{path}} = 6 \times 1 = 6 \Omega$$

$$\frac{1}{R_{\text{eq}}} = \frac{1}{6} + \frac{1}{6} + \frac{1}{6} + \frac{1}{6}$$

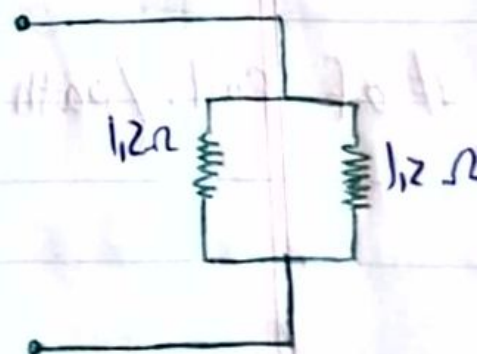
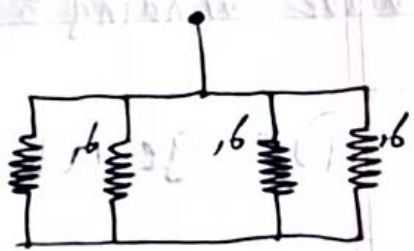
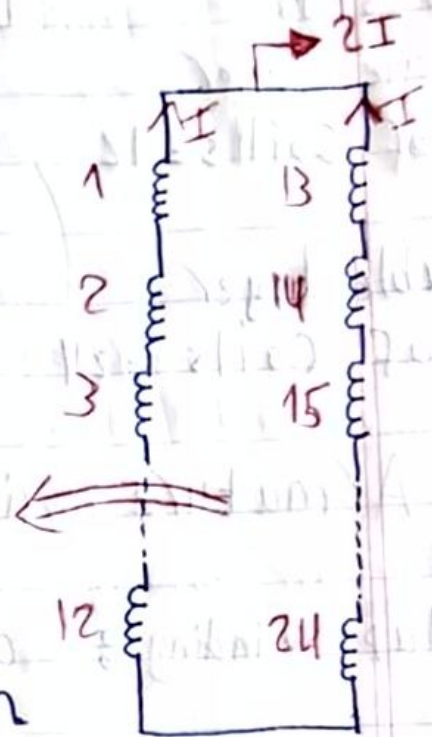
$$R_{\text{eq}} = \frac{6}{4} = 1.5 \Omega$$

* R turn (wave winding) \circ

$$R_{\text{coil}} \Rightarrow 1 \Omega$$

$$R_{\text{path}} = 12 \times 1 = 12 \Omega$$

$$\frac{1}{R_{\text{eq}}} = \frac{1}{12} + \frac{1}{12} \Rightarrow R_{\text{eq}} = \frac{12}{2} = 6 \Omega$$



* Req for armature winding

Armature resistance (R_A)

* equivalent circuit of DC generator

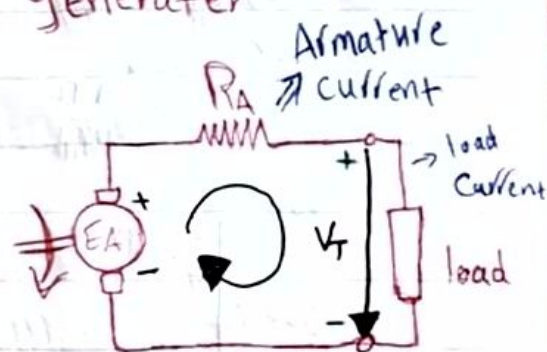
$$E_A = K \Phi \omega$$

Φ : flux [wb] Vs

ω : speed [rad/sec]

K : machine constant

$$K = \frac{Z \times P}{2\pi \times a}$$



* حساب تخطيط V_T لا زيم تعبير E_A

$$100 = 120 - 20, 100 = 105 - 5$$

$$Z = 2CN, P = \# \text{ of poles}, a = \text{mp}$$

حسب النوع or 2m

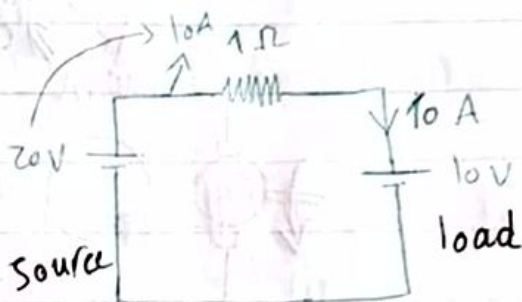
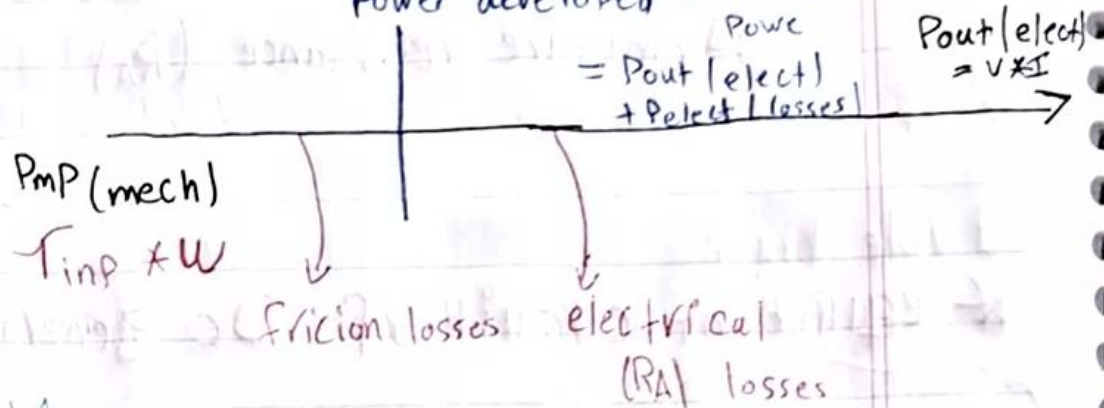
$$-E_A + I_A R_A + V_T = 0$$

$$V_T = E_A - I_A R_A$$

$$V_R = \frac{E_A - V_T}{V_T} \times 100\%$$

Power flow diagram of DC generator

Power developed = total electrical



$$\text{losses} = 10^2 \times 1 = 100 \text{ W}$$

$$P_{out} = 10 \times 10 = 100 \text{ W}$$

$$P_{mp} = 20 \times 10 = 200 \text{ watt}$$

~~induced~~ induced Torque, W

$$T_{ind} = \frac{P_{dev}}{W}$$

Input Torque

$$T_{in} > T_{ind}$$

$$T_{in} = T_{app} = \frac{P_{in}}{W}$$

$$P_{in} = P_{dev} + P_f$$

$$T_{in} = T_{ind} + \left(\frac{P_f}{W} \right)$$

Ex:

* DC generator, $P=4$, 120 slots, each coil consists of 10 turns, simplex lap winding, turn resistance = 1Ω

1) Determine armature resistance (R_A)

of coils $\Rightarrow 60$ coil

$$a = m \cdot p = 1 \times 4 = 4$$

$$\# \text{ of coils/path} = 60 / 4 = 15$$

$$R_{\text{coil}} = 10 \times 1 = 1 \Omega$$

$$R_{\text{path}} = 1 \times 15 = 1.5 \Omega$$

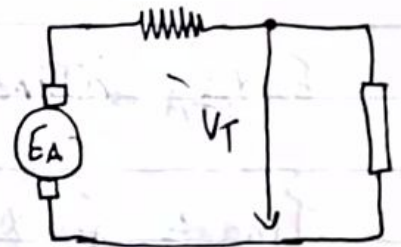
$$\frac{1}{R_{\text{eq}}} = \frac{4}{1.5} \Rightarrow R_A = 0.375 \Omega$$

2) if the flux = 0.2 Wb , Speed = 1200 rpm determine no load voltage

$I_A = 0$ at no load

$$V_T = E_A - I_A R_A$$

$$V_T = E_A$$



$$E_A = K \Phi \times \omega = \frac{Z P}{2 \pi a} \times \Phi \times \overset{\text{speed}}{\omega} \times \frac{2 \pi}{60}$$

$$Z = 2CN = 2 \times 60 \times 10 = 1200 \text{ Conductors}$$

$$= \frac{1200 \times 0.2}{2 \times 4} \times 1200 \times \frac{2 \pi}{60} = 480 \text{ V}$$

3) Determine the speed required for the generator to supply 20 kW, $V_T = 500$ V, $\Phi = 102$ Wb

$$I = \frac{20000}{500} = 40 \text{ A}$$

$$E_A = V_T + I A R_A = 500 + 40 \times 3.75 = 515$$

$$515 = \frac{1200 \times 4}{2\pi \times 4} \times 102 \times \frac{2\pi}{60}$$

$$n =$$

$$\text{or } E_{A1} = K \Phi_1 n_1 \times \frac{2\pi}{60}$$

بما ان التردد ثابت

$$\frac{E_{A1}}{E_{A2}} = \frac{n_1}{n_2}$$

$$E_{A2} = K \Phi n_2 \times \frac{2\pi}{60}$$

$$\frac{480}{515} = \frac{1200}{n_2}$$

$$E_A \times I_A = T_{ind} \times \omega$$

$$n_2 = 1287.5 \text{ rpm}$$

$$T_{ind} = \frac{E_A \times I_A}{\omega}$$

or

$$T_{ind} = \frac{K \Phi \omega \times I_A}{\omega} = K \Phi I_A$$

4) Determine induced torque in case the flux decreased to 50%, $n = 1000$ rpm, $R_{load} = 10 \Omega$

$$E_{A1} = K \Phi \omega = \frac{2\pi}{2\pi a} \times \Phi \times \omega$$

3) Determine the speed required for the generator to supply 20 kW, $V_T = 500$ V, $\Phi = 102$ Wb

$$I = \frac{20000}{500} = 40 \text{ A}$$

$$E_A = V_T + I A R_A = 500 + 40 \times 1.375 = 515$$

$$515 = \frac{1200 \times 4}{2\pi \times 4} \times 102 \times \frac{2\pi}{60}$$

$$n =$$

$$\text{or } E_{A1} = K \Phi_1 n_1 \times \frac{2\pi}{60}$$

بما ان التردد ثابت

$$\frac{E_{A1}}{E_{A2}} = \frac{n_1}{n_2}$$

$$E_{A2} = K \Phi n_2 \times \frac{2\pi}{60}$$

$$\frac{480}{515} = \frac{1200}{n_2}$$

$$E_A \times I_A = T_{ind} \times \omega$$

$$n_2 = 1287.5 \text{ rpm}$$

$$T_{ind} = \frac{E_A \times I_A}{\omega}$$

or

$$T_{ind} = \frac{K \Phi \omega \times I_A}{\omega} = K \Phi I_A$$

4) Determine induced torque in case the flux decreased to 50%, $n = 1000$ rpm, $R_{load} = 10 \Omega$

$$E_{A1} = K \Phi \omega = \frac{2\pi}{2\pi a} \times \Phi \times \omega$$

* Case 1 $E_A = 480 \text{ V}$, $\Phi_1 = 102 \text{ wb}$, $n = 1200 \text{ rpm}$

* Case 2 $E_A = ??$, $\Phi_2 = \frac{1}{2} \Phi_1$, $n = 1000 \text{ rpm}$

$$480 = K \times 1200 \times \frac{2\pi}{60} \times \Phi_1$$

$$E_A = K \times 1000 \times \frac{2\pi}{60} \times \frac{1}{2} \Phi_1$$

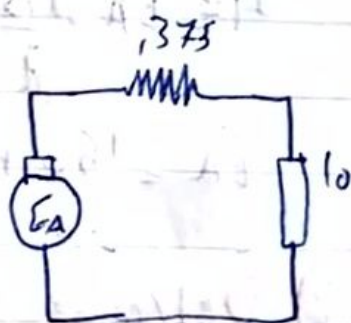
$$\frac{480}{E_A} = \frac{1200}{1000 \times \frac{1}{2}} \Rightarrow E_A = 200$$

$$T_{ind} = \frac{E_A \times I_A}{\omega} = K \Phi I_A$$

$$R_{eq} = 10,375 \Omega$$

$$I_A = \frac{200}{10,375} = 19,27 \text{ A}$$

$$T_{ind} = \frac{200 \times 19,27}{1000 \times \frac{2\pi}{60}}$$



Exo DC generator, $Z = 640$ conductors, simplex lap winding
 $P = 4$, # of coils = 80 coils, ~~$R_A = 2,5$~~
 $R_A = 0,25$

- 1) if the output load = 3 kW, $V_T = 150$ V
 Determine induced voltage E_A

$$E_A = V_T + I_A R_A$$

$$I_1 = I_A = \frac{3000}{150} = 20 \text{ A}$$

$$E_A = 150 + 20 \times 0,25 = 155 \text{ V}$$

- 2) Determine induced Torque for case (1)
 if flux = 0,02 Wb

$$T_{ind} = \frac{E_A \times I_A}{\omega} = \frac{K \Phi \omega i}{\omega} = K \Phi i$$

$$= \frac{ZP}{2\pi a} \times \Phi \times i_A = \frac{640 \times 4}{2\pi \times 4} \times 0,02 \times 20 = 40,76 \text{ N.m}$$

- 3) Determine new induced torque. if current increased 10%
 flux decreased

$$40,7 = K \times \Phi \times i$$

$$T_2 = K \times 0,8 \times 1,1 i$$

$$\frac{40,7}{T_2} = \frac{1}{0,8 \times 1,1} \Rightarrow T_2 = 35,8 \text{ N.m}$$